FOREST PLANTATION RELEASE

What It Is— How To Do It

by

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Plantations of forest trees can be very productive providing a large proportion of the seedlings survive the critical years immediately following planting and conditions for growth are reasonably favorable. Because a certain amount of cultural work generally is needed to assure these conditions and because of the potential value of plantations in Minnesota's forest economy, the Office of Iron Range Resources and Rehabilitation has provided financial assistance in the preparation of this publication.

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INTRODUCTION

Only those forest plantations largely free from competing vegetation will survive, grow, and produce well. Therefore, just as the farmer has to fight agricultural weeds during the early stages of corn, potato, or other crop production, so the forester must combat similar pests during the first few years after the trees are planted. Such weed removal, an operation serving much the same purpose as the cultivation of farm crops, is usually called plantation release. 3/

It is of little use to plant trees if they are not to be given adequate care. For example, an estimated one-third of the 303,500 acres planted to trees in Minnesota through 1953 4/ has failed, mainly because of lack of care after planting.

1/ Maintained by the Forest Service, U. S. Department of Agriculture, at St. Paul, Minnesota, in cooperation with the University of Minnesota.

2/ Research Forester, Headwaters Forest Research Center, Grand Rapids, Minnesota.

3/ It is also known as weeding, cleaning, and occasionally liberation.

4/ Rotty, Roland. Forest and Shelterbelt Planting in the United States During 1953 (July 1, 1952 - June 30, 1953). U. S. Forest Service, Washington. 1953.

Plantation release will become of even greater importance in Minnesota than it has been in the past. An increasing amount of land has been planted in the state since the passage of the Forest Nursery Act of 1947, which permits the sale of trees from the state nurseries for forestry purposes. Moreover, this interest in planting is expected to continue as more and more evidence accumulates as to the early cash returns which coniferous plantations are yielding. Furthermore, most of the easy sites have already been planted leaving the difficult brushy or extremely grassy areas for future work.

To guide the release work necessary on forest plantations in Minnesota, there have been assembled in this publication the most useful and up-to-date methods known. Many of the methods suggested are based on work in progress and are not to be considered final. Although they will apply in general to plantations of any kind, they are intended specifically for the conifers -- pines, spruces, balsam fir, and tamarack -- which have been most commonly used and are most likely to continue to be used for forest planting in the state. These methods can also be used for the release of natural conifers from less valuable trees which are overtopping them.

WHAT RELEASE IS AND WHY PLANTATIONS NEED IT

Plantation release means any operation that removes or reduces competition affecting planted trees. Some plantings suffer from the competition of grass and others from that of annual or perennial herbs. Most of the trouble, however, is caused by shrubs or by small weed trees. But no matter what they are, unless such competitors are kept under control from the start, many of the planted trees will be gradually killed out and the survivors will be stunted in growth and poorly formed. In extreme cases, the plantation may be a total loss. Given adequate release from these weeds, however, the planted trees will regain normal growth and development and soon form fully stocked stands of high value. Yields of such stands may run 50 to 100 percent higher than from plantations where release has been inadequate or lacking (fig. 1).

'A'

'B'

Figure 1.--Lack of release greatly affects yield of red pine: A, Plantation established in 1915 and released in 1931 had a pine volume of 24 cords in 1949. B, Another part of the plantation not released had a pine volume of only 16 cords in 1949. Birch Lake

GENERAL TYPES OF RELEASE

Plantation release is of two general kinds, low release and high release, depending on the size of the competing vegetation to be removed. Low release is the removal of herbs, grasses, low shrubs, or tree sprouts which interfere or threaten to interfere with the growth of the planted trees. Usually it is required during the first 5 to 6 years after planting, but the need may extend over a longer period depending upon the species and class of stock planted and the kind and the density of the woody growth. A special type of low release often needed is from grass or sod. This is generally important in plantations which have been made in old fields but is often needed also in those put in on low ground or moist upland in the more northern part of Minnesota.

High release means the removal of trees and tall brush which are completely overtopping or whipping the planted conifers. The interfering growth may average only a few feet taller than the plantation, or it may form a more or less continuous overstory 20 or more feet taller. Such competition may result from planting conifers under well-established stands, usually of aspen (popple), birch, or oak. Often, however, it grows out of insufficient low release.

Because larger plants must be removed, high release is more expensive than low release, but it should seldom be necessary if the low release operations are carefully and thoroughly done. Plantations which need high release, either because of neglect or of poor low release, have already lost a lot of growth -- growth which is never made up. 5/

WHEN PLANTATIONS NEED RELEASE

Release should be given as soon as the surrounding vegetation begins to show signs of interfering with the planted conifers. During the first year low cover affords some protection to a newly established plantation, but after that period the young trees can easily cope with ordinary climatic conditions and should not be allowed to get lost in the brush or grass. Once such a plantation has been released, it should be watched closely to see that the weeds do not again get out of hand. Maintenance of good growing conditions by a few light releases will be more effective than a heavy release after weed species have severely overtopped a plantation.

5/ A red pine plantation on the Superior National Forest in which release was delayed for 17 years had a pine volume of only 24 cords at age 38 compared to 35 cords where the plantation was never overtopped.

Rapidly growing species like jack pine can often keep ahead of competing vegetation without release of any kind, but this is not generally true of such conifers as red pine, white pine, and white spruce. Although white spruce and balsam fir can stand considerable competition without serious loss in stocking, their growth is greatly reduced. Early release is, therefore, as essential for these conifers as it is for the less tolerant ones. Although release should usually be complete, white pine plantations are far less subject to severe attack by the white pine weevil if at least a light overhead cover is retained.

The importance of early release is strikingly pointed out by a white spruce plantation established in 1940 on the Marcell District of the Chippewa National Forest. In the part of this plantation which was released 2 years after planting, there are now 1,320 spruce compared to 715 per acre where no release was given Moreover. 80 percent of the released trees are 1 inch and up in diameter compared to only 30 percent where the spruce is overtopped

HOW TO RELEASE PLANTATIONS

LOW RELEASE

Of the two general kinds of release, low release is the more important for, if properly done, it often can make expensive high release unnecessary.

There are two main types of low release:

1. Release from grass and sod.
2. Release from brush, herbs, and tree sprouts.

Release From Grass and Sod

When and Where Needed

Plantings put in w thout prior ground preparation on old fields and abandoned pastures or on large burns which have converted to sod usually need their first release from grass and sod during the first growing season after planting, even when planting machines are used. On the other hand, plantations on sod which has been furrowed, disked, or scalped may not need release until the second or third growing season because of the time required for the grass to recover and outgrow the trees. Cases are reported in which jack pine planted in furrows has grown parallel to the ground for 2 or 3 feet because of the matting of grass over the furrows.

Type of Competition

A dense sod of perennial grasses, such as quack grass, bluegrass, redtop, and certain sedges, furnishes extreme competition for soil moisture and nutrients. On the better sites where the grass grows taller, planted conifers may also suffer from reduced light and may eventually be smothered by the matted dead grass. This is particularly true in the northern part of the state. Here the moister sites tend to come back to a tall, dense growth of bluejoint grass once they have been opened up or burned. Tall grass also furnishes a good home for mice which may cause considerable damage to the planted trees in some winters.

How To Do It

Release plantations where grass is outgrowing and holding back most of the trees by cutting away the sod in a circle 6 inches to 1 foot in radius around each tree. The size of scalp depends on the density and height of the grassy cover. Scalps must be large enough so that the dead grass in between them will not fall in mats on the conifers. Repeat the job when needed (fig. 2).

Figure 2.--Grass release by means of scalping with a hoe.

Tools successfully used for grass release are heavy hoes, grub hoes, or mattocks (fig. 3). For best results, do the work in late June and July. Use care to avoid cutting the tops or injuring the roots of the trees.

Crew organization can be the same as used in planting -- one foreman for each 10-man crew. Assign each man a row of trees to release. Production in grass and sod release is quite variable, depending on size of stock and density of grass cover. No successful chemical methods of obtaining grass release are known so far. However, one or two companies are introducing products which kill grass in agricultural crops, and these may have application in grass release.

Figure 3.--Typical tools used in grass release of coniferous plantations. Light grub hoe (on left), hoe, and mattock (right).

Release From Brush, Herbs, and Tree Sprouts

When and Where Needed

Plantat ons other than tho put in on old fields, abandoned pastures and gra sy areas usually need one to severa. low release jobs dur ng the r first six growin, seasons. The number of releases required de ends on the dens ty of cove , the species planted, and whether or not the area was given prior ground preparation such as disking. Where no gr und preparat on was used and the brush is heavy, release m.y be necessary fo all pecies during their first growing season. On undisked areas wi th light to moderate brush, plantation release can be delayed until the econd year except for red pine which should b released dur ng its irst year. Jack pine needs the least release and red pine the most, with white spruce and white pine intermediate. Similarly, seedling st ck needs more care than transplants. Planted conifers can be brought through with one or not more than two release jobs on disked areas, if the disking has been well done and at the proper time, compared o the three or more needed on undisked areas. Release on di ked areas is not needed until about the third or fourth year

Furrowing cann t e regarded as a substitute for disking on brushy areas due to the height handicap given the tree by the depth of the furrow and the tendency of brush to spread out over the furrows. Therefore, trees in fu rows will need as many releases as those planted on similar land which has not been furrowed.

Type of Competition

On undisked areas, competi o s may con ist of some of the following sh ubs hazel, a der (tag or speckled on mo st sites, green on drier so ls), willow, cherry, raspberry, blackberry, rose, Juneberry or serviceberry, sweetf rn, mountain maple, blueberry, and others; and of aspen suckers and sprouts of birch, red maple, and other hardwood trees. Common herbs are brake and other ferns, climbing buckwheat, goldenrod aster, bush honeysuckle, nettles, and sma l amounts of various grasses. Many disked areas are invaded a year after treatment by a heavy growth of annual weeds such as horseweed, hempnettle, or by the flowering stalks of largeleaf aster. These offer some competition at first but usually are much less abundant suc eeding years.

All of these weedy plants offer competition for soil moisture and nutrients and greatly reduce light intensity where they form a dense cover. Another indi ect source of loss is nipping of the trees by hares or rabbits which are urnished good protection from their natural enemies by the brush.

How To Do It

Cut back brush, herbs, and tree sprouts which are within a radius of 18 inches and have the ability to outgrow the planted trees. Outside of this zone, cut all vigorous brush, sprouts, and aspen suckers which can overgrow the space made for the planted trees and will be a potential source of competition. Such release will free individual trees and yet afford enough protection that they will not be completely exposed to sunlight and winds. Do not release the leader alone because the lower whorls of branches also need light so they can make the food necessary for active growth.

Tools commonly used are the brush scythe, brush hook, corn knife, machete, and a commercial adaptation of the machete called the "Woodsman's Pal" 6/ (fig. 4). The choice is largely a matter of preference for all will do a good job if kept well sharpened. Long-handled tools such as brush scythes and brush hooks cannot be as closely controlled as implements with shorter handles, so special care must be taken with them to avoid cutting off the trees to be released.

Low release is most effective when done in late June and July. Brush cut during this period will resprout least as food reserves in roots are then at their lowest level. Conifers released during this time will have at least a partial season with good growing conditions.

Use one foreman with each crew of 10 men as in grass release and in planting. In releasing small trees from dense cover, less injury will be caused the trees if the men work in pairs, each of which is assigned a row of trees. The first man removes the competing cover by hand, or with a sickle or other small tool, within a circle of 6 inches around each tree; the second finishes the job with a brush scythe or similar tool (fig. 5). Where the cover is less dense or the trees are smaller, the men can work individually.

Areas where the trees are large and competition not too heavy may require as little as 1 man-day per acre for brush release. On the other hand, plantations where the trees are small and hard to find and the cover heavy may require up to 5 man-days per acre. Chemical herbicides show great promise in speeding up brush release and reducing its cost.

6/ Other new tools that would seem to have promise but have not yet been thoroughly tested are the imported "bush-axe" and small power-operated circular saws and scythes.

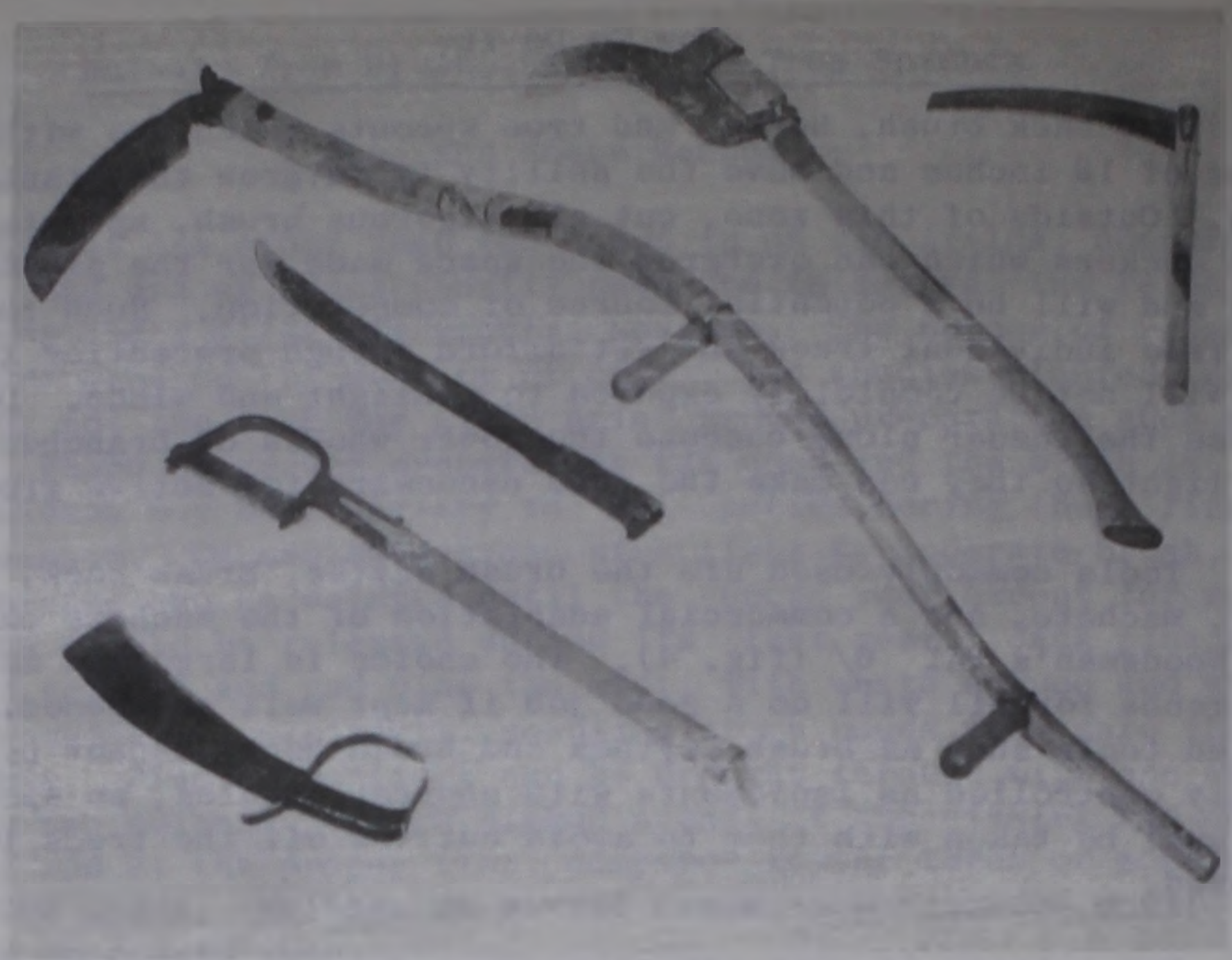

Figure 4.--Typical hand tools used in low release of coniferous plantations. "Woodsman's Pal" with hook removed for safety (on left), "bush-axe," machete, brush scythe, brush hook, and corn knife (on right).

Figure 5.--Low release from brush. One man removes weeds close to the conifers by hand or with hand tools; the other cuts remaining competitors with brush scythe.

Possibilities of Herbicides in Brush Release

Spraying with chemical herbicides to kill the competing vegetation is a new approach that seems to have considerable possibilities both of speeding up brush release and cutting its cost. Weak solutions of the low volatile esters of 2,4-D or of 2,4,5-T (or mixtures of these chemicals) are applied when the foliage of the brush is at full development. The chemicals are absorbed by the plants and cause death of the stems, and in some cases the roots, in most species except for the grasses and allied plants. Fortunately, conifers as a group are relatively resistant to injury. However, pine trees can be injured, particularly if they are sprayed during the early part of the growing season. The chemicals are non-poisonous to man or wildlife.

Only a limited amount of brush release by spraying with the chemical herbicides has been done so far in Minnesota. Back-pack pumps have been used but are practical only for small areas (fig. 6). Power pumps mounted in trucks, in trailers pulled by a jeep, or on "cat wagons" seem to be satisfactory. Such pumps may be quipped with a boom with several nozzles or with one or two hose lines For extensive areas of low brush, aerial application seems very promising.

Figure 6.--Low release by spraying foliage of overtopping brush with chemical herbicides.

In applying chemical herbicides, the user should be guided by the manufacturer's suggestions. On the basis of work done thus far, satisfactory top kill of such common brush species as hazel, willow, and alder, and of many common herbs, can be obtained by applying 30 to 50 gallons per acre of a water solution containing 1 to 2 pounds of pure 2,4-D (acid) per 100 gallons. Other competing species are killed only by the similar chemical 2,4,5-T, so it is often necessary to apply the two in mixture. There is considerable resprouting the second year from most species of woody plants, just as there is from hand-cut brush. Repeat applications may, therefore, be necessary to do an effective job of release of young plantations in heavy brush.

For plantation release involving woody plants, only the ester formulations of these two chemicals should be used. Since there is always a chance of injuring crops on neighboring lands by drift, spraying should be done only when the air is calm. The foliage of the vegetation to be sprayed should be relatively dry. Although the brush can be killed back to the ground by spraying at any time after the leaves are well developed, resprouting is lessened in most species if the work is done in mid-growing season (July). However, pine plantations may be injured by the herbicides at this time, so it is better to delay release spraying of these until early August when the new growth of conifers will have hardened off.

Very little data have been obtained so far on the cost of low release by spraying. Present indications are that ground spraying with power equipment will cost from about $5 to $15 per acre; estimates on aerial spraying indicate costs of $5 to $6 per acre.

HIGH RELEASE

When and Where Needed

High release will be needed sooner or later in plantations established under moderate to heavy overstories of aspen, birch, or oak. It also is required in plantations overtopped by hardwoods and tall brush through neglect or insufficient low release. Ordinarily, high release should begin when the planted trees are 4 to 5 feet tall; however, if there is any loss of height growth the work should be done without delay so that the planted trees do not become badly suppressed. One job well done should be sufficient except where the released conifers (1) average less than 3 feet in height and thus may be outgrown by the subsequent sprouts and aspen suckers, or (2) consist of white pine which may be exposed to sun scald or to excessive weevil injury. Such plantations should be released in 2 or occasionally 3 light operations at 2- or 3-year intervals.

Type of Competition

In plantations needing high release, the overtopping competitors include the same trees -- aspen, birch, oak, and other hardwoods -- and many of the same shrubs that make low release necessary. The more important shrubs are those which often make small trees -- willow, tag alder, pin cherry, choke cherry, Juneberry, mountain maple, and, in some areas, hazel.

The loss from such competition is even more serious than that caused by low brush and sprouts. Many of the planted conifers are literally suppressed to death, and the survivors suffer a great loss in growth. Planted trees at this stage have passed the slow growth period and would grow very rapidly if given the chance. The yield of long-overtopped plantations consequently is only a fraction of that produced by plantations which have received adequate early release, and the longer such competition continues the smaller the return will be. Another source of loss is through injury caused to the leaders by their being whipped or rubbed by the branches of taller trees or brush. This may cause forking, crook, or the loss of several years' height growth. Hares and rabbits often continue to nip the trees, particularly during the winter months when the snow blanket enables them to reach the higher branches and further aggravate the losses in stocking and in growth.

How To Do It

Release plantations from all tall brush and trees which are directly overhead so the conifers can grow up through the openings in the canopy. Leave enough side competition so that the planted trees will not develop heavy branches. The amount of side release needed depends almost entirely on the height of the overtopping trees and brush. For instance, 5-foot pines and spruces overtopped by aspen and birch which is only 15 feet high require less side release than similar conifers under an overstory averaging 30 feet in height. Since there is a tendency to leave too much overstory in most high release jobs; the best rule to follow is to remove the competitors in all cases where there is any doubt. Because of the very fast growth made by aspen and birch when given additional room, release must not be too conservative or it will be necessary to come back in 4 or 5 more years to do the job over.

The amount of overhead cover that can be permitted in fully stocked plantations varies with the species planted and the time elapsed since planting (table 1).

Table 1.--Maximum density of overstory that should be tolerated in fully stocked plantations

Species	Years after planting			
	1 - 5	5 - 10	10 - 15	15 - 20
	Percent	Percent	Percent	Percent
Jack pine	20	0	0	0
Red pine	30	15	0	0
White pine	37	25	10	0
White spruce	40	30	20	15

Although trees and tall brush are like low brush in showing less resprouting when cut in July, much high release can be done at any time of the year. Plantations of small, badly suppressed conifers which are likely to be overtopped by the resulting sprouts should be released in midsummer. Where the conifers average more than 3 feet in height, the work can be done at any convenient season. Where the work involves the felling of large trees, however, extremely cold weather should be avoided. At such times the frozen twigs and branches of the conifers are very brittle and are easily damaged.

The forest manager faced with a large amount of high release should put his plantations into priority groups based on the relative tolerance of shade of the conifers represented and their stocking. Jack pine and tamarack can tolerate less shade than red pine, white pine, and spruce and do not enter the high release picture; plantations of these species which have been so neglected as to reach the high release stage are usually so understocked as to be failures. Considering plantations of about equal stocking, red pine should receive highest priority, followed by black spruce, white pine, white spruce, and balsam fir in descending order. However, it may be better business to release a well-stocked plantation of a relatively tolerant tree like white spruce before work is begun on a poorer stocked planting of the relatively intolerant red pine.

High release of planted conifers can be effected by any one of three general methods:

1. Cutting the competing trees and shrubs with hand or power tools.

2. Girdling the trees and cutting the shrubs.

3. Treating the competitors with chemical herbicides.

Cutting Overtopping Trees and Shrubs

The most common method of high release has been to cut the competing trees and brush at any convenient height, using $2\frac{1}{2}$- to 3-pound double-bit axes for material averaging 4 inches and larger in diameter (fig. 7). For smaller stems lighter tools are preferable. These include the machete, the "Woodsman's Pal," tools developed locally during the C.C.C. program such as the "Phelps Tool" (Vilas County, Wisconsin) and the "Finn Hook" (northeastern Minnesota), and the "bush-axe" imported from Sweden (fig. 8). When the overstory includes merchantable aspen and paper birch, the release can often be accomplished by carefully logging the overstory for pulpwood and other products. Where a near-merchantable stand of these trees overtops a plantation of the more tolerant conifer which is making good growth, it may be worthwhile to keep the overstory until it reaches loggable size.

Figure 7.--High release by cutting overtopping trees.

Figure 8.--Cutting tools used in high release of planted conifers. "Woodsman's Pal" (on left), machete, "bush-axe," double-bit axe, locally made cutting hook, and Phelps tool (on right).

In an effort to cut costs, the Marcell Ranger District of the Chippewa National Forest has worked out a mechanical method which is very satisfactory. Trees 3 inches and larger are felled with a power saw and the smaller ones and brush cut by hand. The overtopping aspen and birch are cut only enough to get them down out of the way of the conifers. Some 380 acres of planted pine have been so released over a 3-year period with no lost-time accidents.

In high release with the common hand tools, use one foreman to each 6- or 7-man crew. In the power saw release at Marcell, a 5-man crew has proven best. One man operates the saw assisted by a man who guides the fall of the tree with a pike pole. Two others fell the smaller trees and tall brush with axes and lop the crowns of the down trees wherever they interfere with the conifers. The fifth man acts as foreman.

The cost of high release by hand cutting naturally will vary with the amount of overtopping trees and brush removed. Plantations which need only a moderate degree of release may require only 0.6 to 1.0 man-day per acre, but jobs where the cutting has to be heavier may take up to 3 man-days per acre. Power saw release requires about 0.25 man-day per acre where a moderate amount of cover is removed and hence appears to be considerably faster than hand work.

Girdling Overtopping Trees

Girdling, particularly of large unmerchantable trees which cannot be cut without causing considerable injury to the conifers, is often used in high release, either as a substitute for or a supplement to felling. This consists of removing the bark and inner bark or cambium and sometimes a narrow layer of sapwood in a ring completely around the trees. Girdled trees die rather slowly and fall to the ground piece by piece over a long period. As a result, release by this method is considerably more gradual than that by cutting, and breakage of the planted conifers is usually slight. Girdling is a good method to use in the release of white pine to minimize the danger of sun scald and of weevil attack.

Girdle trees 4 inches and larger (for smaller trees cutting is faster) by one of two methods:

1. Removal of a strip or collar of bark and attached cambium by peeling.

2. Notching or cutting through the bark into the wood so as to remove a continuous chip.

Peel-girdle with a light axe, a draw shave, or a Phelps tool, or make 2 parallel cuts around the tree and about 6 inches apart with a girdling saw so that the bark can be slipped off in a long ribbon (figs. 9 and 10). 7/ In peeling with a draw shave or axe, all traces of cambium must be removed for even a strip bridging the gap will continue to grow and keep the tree from dying. Peeling works fairly well in aspen but rather poorly in birch. It can be done best during the few summer months when the bark slips easily.

7/ Another tool which would seem to be useful in girdling by this method but which has not been thoroughly tested in Minnesota is the "Handigirdler" made by the Utility Tool & Body Co., Marion, Wisconsin. Information on other girdlers of this type may be obtained from the American Pulpwood Association, New York City.

Figure 9.--High release by girdling overtopping trees with a light axe.

Notch-girdle by removing a 3- to 4-inch band of bark and sapwood between two double hacks made with an axe. Notching is the only feasible type of girdling to use during winter months.

Use one foreman for each 6- or 7-man crew as in high release by hand cutting. No cost data are available for Minnesota; elsewhere it has been found that one man can girdle from 50 to 90 square feet of basal area per day. Of the two methods, notching is the cheaper.

Figure 10.--Girdling tools used in high release of planted conifers. Draw shave (on left), double-bit axe, Phelps tool (right), and girdling chain saw (at top).

Treating Competitors with Chemical Herbicides

Chemical herbicides have proven of considerable value in high release elsewhere in the Lake States and are being used more and more for such work in Minnesota. Of the three different types of application that have been developed, cut-surface treatment is so far the most feasible. Basal spraying is much less satisfactory because of its greater cost, but foliage spraying from aircraft, although not thoroughly worked out, appears to have great possibilities in both high and low release.

Cut-surface treatment of trees and shrubs

Cut-surface treatments (there are two general methods) require the use of hand tools to expose living wood and chemicals with which to treat it. The more common method is to cut the small trees and shrubs and frill-girdle the larger trees, followed by treating the stumps and frills with a solution of either 2,4,5-T or ammate.

The following technique is suggested:

First, make up a supply of herbicide solution, using one of the low-volatile ester formulations of 2,4,5-T mixed with No. 2 fuel oil or diesel oil 8/ at a concentration of 4 to 8 pounds of the pure acid (i.e., pure 2,4,5-T) per 100 gallons of solution. Where the trees to be killed are mainly aspen, use 8 to 12 pounds of acid per 100 gallons. Such concentrations will require 1 to 2 gallons and 2 to 3 gallons respectively of an ester formulation with an acid equivalent of 4 pounds per gallon. To any of these amounts, add enough oil to make 100 gallons of mix. Add 1/2 to 3/4 pound of oil soluble dye per 100 gallons of solution to make treated frills and stumps easy to spot. Para red is a satisfactory dye. Do not use water-soluble dyes as they will clog the screens and nozzles.

Then, cut trees up to 3 or 4 inches in diameter with axes or any other convenient tool and girdle larger ones at a convenient height by making a single hack frill of overlapping cuts with the same tool.

Third, using a knapsack sprayer, spray the cut surfaces with herbicide solution within a few minutes after cutting and frilling (fig. 11); soak the stumps thoroughly not only on the top but also on the side. Use a rather coarse spray and a moderate pressure.

To keep resprouting at a minimum, do chemical frill release from late June through July. Planted conifers averaging 4 or more feet in height, however, are not likely to be outgrown by sprouts and, if summer release is inconvenient, the overtopping trees can be treated at any season. When treating frills in midsummer, avoid getting spray solution on the conifers, especially pines, as they are easily burned by the herbicide during their active growing season.

8/ Water has proven unsatisfactory as a carrier of 2,4,5-T in frill treatment in the Lake States.

Figure 11.--High release by means of spraying frill-girdled trees with 2,4,5-T in oil.

Very convenient are sprayers developing pressure from a pump operated with the right hand and having a trigger shutoff valve operated by the other hand; those with the trombone type of pump are not satisfactory. Nozzles should be adjustable. Knapsack sprayers usually are of 5-gallon capacity, but it will be less fatiguing to carry only about 3 gallons of solution.

In the absence of pressure-spraying equipment, a simple substitute can be easily made from a 2-gallon lubricating oil can mounted on a packboard. Solder a short length of 1/8-inch pipe or copper tubing to the bottom of the can. Attach to this about 3 feet of oil-resistant hose with a 1- or 2-foot length of 1/8-inch aluminum pipe inserted in its other end. An ordinary clip-type tubing clamp will serve as a shut-off valve. Total cost should be about a dollar. Such a gravity applicator cannot, of course, be used as rapidly as a pressure sprayer and will require lower frills (fig. 12). If desired, an ammate solution consisting of 2 to 4 pounds of the crystals dissolved in a gallon of water can be used to treat fr hl cut stumps and frills. 9/ In that case, sprayers should not be used as the solution is very corrosive. Instead, it should be poured from glass jugs with a short length of 1/4-inch brass or copper tubing soldered to the cap.

In chemical frill release, use 2 to 3 men for each man applying the herbicide. A good foreman can supervise two such crews. Costs under Minnesota conditions have not been worked out. They should be somewhat higher than ordinary hand cutting and frilling because of the cost of the chemical. However, this disadvantage will be more than offset by the reduction in sprouting brought about by the herbicide.

Basal spraying

This method consists of spraying the trunks of trees and larger brush with oil solutions of 2,4,5-T from the ground up to 2 or 3 feet. It requires large amounts of an expensive ch mical and is, therefore, not generally recommended. However, it is the best method known thus far of controlling tall mountain maple.

Aerial spraying

In high release work, applying foliage sprays with ground-operated equipment is impractical because of such obstacles as the type of competing growth and inaccessibility due to location, topography or poor drainage. Spraying from aircraft wou d, th refore, seem to be the only logical alternative and because of its inherent possibilities

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9/ Low-grade oaks and other hardwoods have been killed on thousands of acres in the South by dry ammate crystals applied in notches or cups cut in the base of standing trees and on the stumps of smaller ones. This, the second cut-surface method could likely be used in Minnesota but requires large outlays for labor and for the salt.

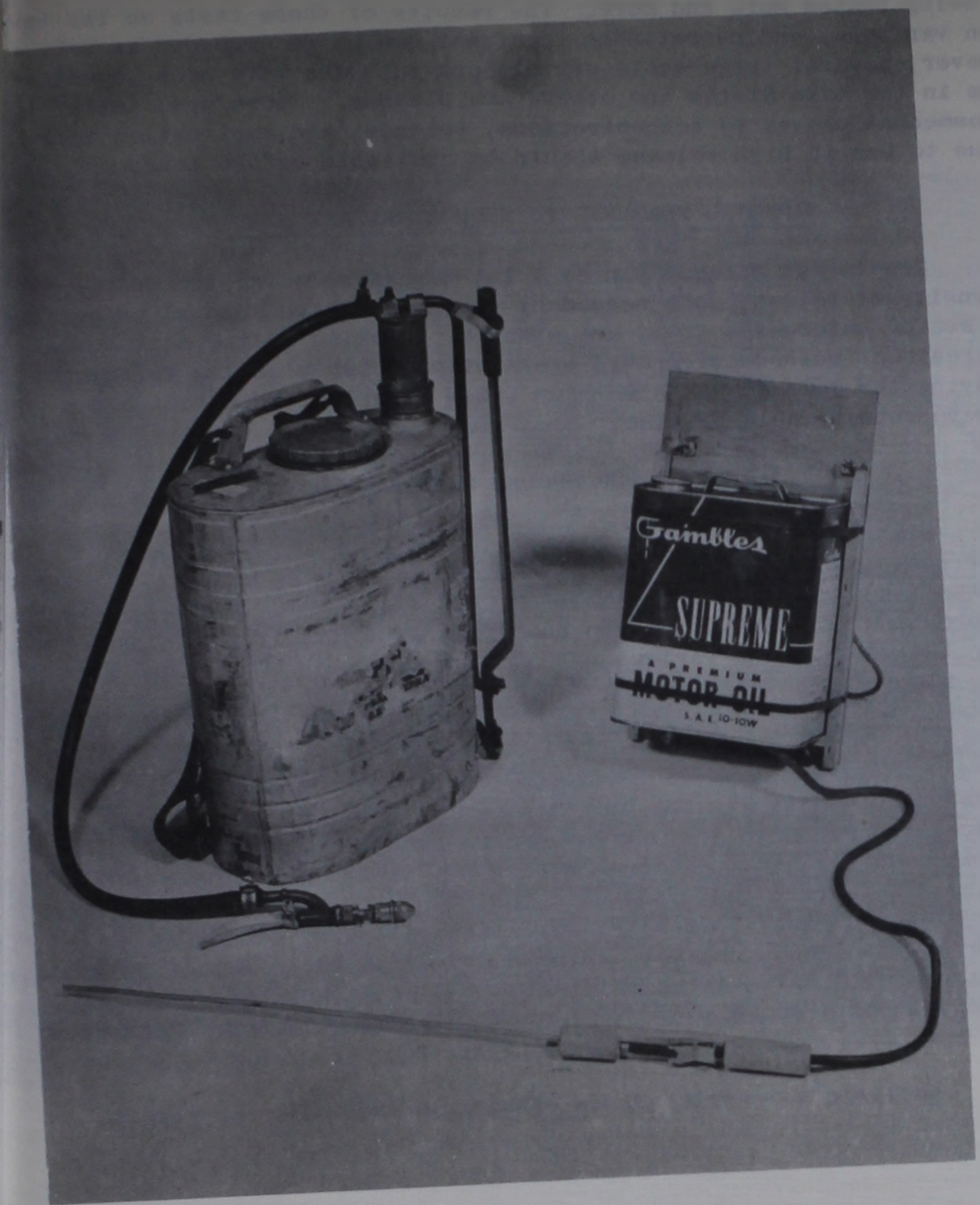

Figure 12.--Equipment used in high release by means of cut-surface treatment with 2,4,5-T. Knapsack sprayer which builds up pressure by means of pump operated with the right hand (on left); herbicide applicator (on right) after D. B. Cook (Down-To-Earth 9(3): 5; 1953.).

is being tested more and more. The results of these tests so far have been variable, and no reliable treatment can be recommended as yet. However, several large-scale aerial spraying jobs have been recently done in the Lake States and others are planned. Therefore, definite recommendations as to concentrations, volumes, and application technique to use in high release should be available before long.

SPECIAL MEASURES TO REDUCE RELEASE NEED

The forest manager can do a lot toward reducing the number and intensity of release jobs needed by giving the site special preparation the season before the trees are planted. Disking is the most common pretreatment method but ground preparation or preplanting release by spraying the foliage has also been tried to a limited extent and seems to have considerable promise.

DISKING FOR GROUND PREPARATION

Using a 40- to 60-hp. tractor to pull a heavy fireline disk, cover the planting site thoroughly -- once if 2 disk units are arranged in tandem and twice if but 1 unit is used (fig. 13). For best reduction in sprouting the work should be done in late June, July, and early August as in the case of the various release operations. If disking is well done, plantations can be brought through with only 1 or not more than 2 release jobs, instead of the 3 or 4 usually needed on untreated areas.

Disking has important effects on survival, height growth, and release need as illustrated by a test of planted red pine (table 2). Although the pines on the untreated area show slightly higher survival, they are shorter and much more in need of release than those put in after disking. This test indicates also that too much disking can be done; plots disked in August 1945 and again the following summer show decided poorer survival and much more release need than those disked only once. Here the additional disking eliminated the brush but encouraged the development of a dense sod. Therefore, redisking is not recommended.

Figure 13.--Disking to prepare brushy sites for planting.

Table 2.--Effect of ground preparation on survival, height growth, and release need 3 to 4 years later of planted red pine (Chippewa National Forest)

Type of ground preparation	Survival	Average height	Release need 1/
	Percent	Feet	Percent
None	89	1.4	55
Moderate disking (August 1945)	77	1.9	9
Heavy disking (August 1945)	81	1.7	18
Moderate disking (August 1945; redisked August 1946) 2/	61	.8	44
Heavy disking (August 1945; redisked August 1946) 2/	65	.9	31

1/ Based on living survivors only.
2/ Trees planted in 1947; preceding treatments planted in 1946.

FOLIAGE SPRAYING FOR PREPLANTING RELEASE

Spraying of this kind is done using the same formulations and concentrations as in low release with herbicides. Since there are no conifers to be injured, such spraying can be done in late June and July when the food reserves of the brush are at their lowest level. Also, this type of prerelease can be followed by machine planting, an impossibility where disking is used because of the rough condition in which the surface is left.

Results obtained thus far with foliage sprays, while not perfect, are encouraging and improvement can be expected as new methods of application and new chemicals are developed. For example, 4 years after planting red pine had better survival and growth, less hare damage, and less need for release on the area given preplanting chemical release tha on the untreated area (table 3).

Table 3.--Survival, average height, release need, and hare damage in 1953 of red pine machine-planted in 1950 with and without chemical prerelease

Site preparation	Survival 1953	Average height 1953	Release need	Hare damage
	Percent	Inches	Percent	Percent
Prereleased with herbicide	86	21	42	21
None	76	13	71	71

The prereleased portion of this plantation can be pulled through with one inexpensive release job; the unsprayed portion will require much more attention and since the brush is larger the first job will be costly. Of special interest is the reduction in the number of trees nipped by hares on the presprayed area, undoubtedly the result of the poorer cover afforded the animals.

SAFETY MEASURES

Plantation release, like all other operations in forest management, involves accident hazards which must be recognized and avoided so far as possible. Otherwise serious injury and even loss of life may occur.

Hand tools are the major potential source of accidents on release jobs. As stressed under low release, effective operations mean sharp tools, and sharp tools will cause trouble if not handled with proper respect. Tools such as axes, machetes, "Woodsman's Pals," Phelps tools, etc., should always be kept in sheaths when not in use. Sheathing such tools not only reduces the chances of accidents, but also keeps them sharp longer and protects them from nicked edges. Shin guards afford excellent protection against leg cuts and should be supplied the workers on large jobs. Shoes with safety toes are also worthwhile, and arrangements perhaps can be made to furnish these to the workers at cost.

The foreman in charge of a release crew should be safety conscious at all times and thus be on constant lookout for poor work habits which might lead to accidents. Any such habits should be corrected immediately. In this connection, it is suggested that all foremen on jobs of this type be thoroughly familiar with such safety guides as the U. S. Forest Service Safety Code.

High release involves the additional hazard of falling trees and branches. Hard hats should, therefore, be worn in all operations of this kind. Where power saws are used, extreme care is necessary since felling is so rapid as to introduce somewhat of an element of surprise to those not familiar with the operation of this modern tool.

In addition to accidents stemming from the use of hand and other tools, the foreman should be on guard against poison ivy. This common plant, a low shrub in most of Minnesota, causes a severe rash on most persons and should be avoided as much as possible. Where poison ivy has to be cut or otherwise handled in low release jobs, the men should wear cotton or other gloves (a wise precaution when using hand tools at any time) and keep their arms covered. At the close of the day they should be warned to bathe any parts of their bodies suspected of coming in contact with the leaves or stems with yellow laundry soap. Persons who have a history of extreme sensitivity to poison ivy should not be employed on release jobs where this shrub commonly occurs.

Release methods using chemical herbicides, aside from the special hazards involved in aerial spraying, generally involves fewer accident hazards than those using hand tools. Pressures in both hand and power sprayers should not be allowed to build up beyond a safe limit. On the former, substantial hose clamps, better than those commonly furnished with the pumps, should be installed. The oil used as a carrier for 2,4,5-T in basal and cut-surface treatments may cause burns to the body of the operator and is, of course, somewhat inflammable. Leaky tanks, hose, or shutoff valves should, therefore, not be tolerated. All sprayer of the knapsack type should have a tight gasket of oil-resistant rubber under the filler cap.

In aerial spraying operations at least the minimum requirements of the U. S. Civil Aeronautics Administration as regards the safety of commercial pilots should be insisted upon.

RESEARCH BEING DONE

Considerable experimental work is being done in Minnesota and elsewhere in the Lake States aimed at improving plantation release and lowering its cost. Since the most promising approach to these objectives is through chemical brush control, practically all the studies are in this field. Under way or planned are:

1. Studies of concentrations and time of application of new chemicals.

2. Further tests of aerial spraying on a sizable scale, including volume, nozzle size, marking, repeat applications.

3. Simulation of aerial application so that very exact amounts of the common herbicide solutions can be applied uniformly to small areas.

4. Detailed studies of application -- type, season, concentration, etc. -- using 2,4-D and 2,4,5-T on the common species of brush and perennial herbs. (These are needed because most of the work to date has been more or less on a trial-and-error basis.)

5. Effect of repeat applications made the following year.

In view of the development of new girdling tools and power-operated brush saws and scythes, these aids to release are also planned for evaluation.